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The Impact and Role of the Digital Economy on the Resilience of the Real Economy

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Abstract

This study investigates how the digital economy takes shape within and influences the resilience of the traditional real economy. Integrating theoretical analysis with practical application insights, it explores the pervasiveness of digital technologies across the entire value chain—encompassing production, distribution, consumption, and even post-consumption services. The analysis reveals that digital technologies significantly enhance the adaptability and recovery capacity of economic systems amid shocks and disasters, primarily by optimizing resource utilization efficiency, stimulating innovative activities, and fostering inter-organizational collaboration. Furthermore, this study identifies and elaborates on the major obstacles hindering the transition from a traditional economic system to a digital-driven model, including the digital divide, technological integration barriers, and regulatory mismatches. It ultimately proposes a comprehensive policy framework aimed at creating a more inclusive, secure, and sustainable development model that maximizes the digital economy's empowering effect on real economy resilience.

Keywords

Digital Economy, Resilience of the Real Economy, Impact Mechanisms, Digital Transformation, Empowerment Pathways, Inclusive Development, Data Governance

1. Introduction

In an era marked by increasing global volatility—characterized by frequent geopolitical conflicts, recurrent public health crises (such as the COVID-19 pandemic), and abrupt shifts in global supply chains—the resilience of the real economy has emerged as a critical cornerstone for maintaining macroeconomic stability and sustainable growth. The real economy, as the backbone of national economic development, encompasses industries such as manufacturing, agriculture, energy, and

traditional services, which provide essential goods and services and underpin employment and social stability. Resilience, in this context, refers to the ability of economic systems, industries, and enterprises to withstand external shocks, adapt to changing environments, and rapidly recover and even achieve transformative growth post-disruption.

Digital technologies, led by big data, artificial intelligence (AI), cloud computing, the Internet of Things (IoT), and blockchain, are profoundly reshaping the operational logic and structural composition of the traditional economy. Beyond improving productivity and operational efficiency, these technologies are redefining how business entities measure, manage, and enhance their risk resistance capabilities. The integration of digital technologies into the real economy has become an irreversible trend, with profound implications for its resilience. For instance, during the COVID-19 pandemic, enterprises that had adopted digital tools such as remote collaboration platforms, online sales channels, and intelligent production systems were better able to mitigate the impact of lockdown measures and supply chain disruptions compared to their non-digital counterparts.

Against this backdrop, understanding the intrinsic connection between the digital economy and real economy resilience has become an urgent academic and practical imperative. This research not only explores the specific mechanisms through which the digital economy enhances real economy resilience but also delves into the practical dilemmas and challenges encountered in this process. By addressing these issues and proposing targeted strategies, this study aims to provide theoretical guidance and policy references for promoting the deep integration of the digital and real economies and enhancing the overall resilience of the economic system.

2. Theoretical Foundations of Digital Economy and Resilience of the Real Economy

2.1 Core Conceptual Definitions of Digital Economy and Resilience of the Real Economy

The digital economy, as a new economic form driven by data as the core production factor, relies on digital technologies such as AI, big data, and cloud computing to realize the efficient allocation of resources and the innovation of business models. Its scope extends beyond emerging digital industries (e.g., e-commerce platforms, fintech) to include the digital transformation of traditional industries. The foundational components of the digital economy include not only tangible digital infrastructures (such as 5G base stations, data centers, and IoT sensors) but also intangible elements such as data resources, digital algorithms, and digital skills. Unlike the traditional economy, which is primarily driven by physical resources (e.g., labor, capital, land), the digital economy exhibits characteristics of high permeability, strong spillover effects, and network externalities—enabling it to penetrate all aspects of the real economy and drive systemic changes.

The resilience of the real economy is a multi-dimensional concept that encompasses three core dimensions: resistance, adaptability, and recovery. Resistance refers to the ability of the real economy to minimize losses when facing external shocks (e.g., supply chain disruptions, market fluctuations, or policy changes). Adaptability refers to the capacity to adjust operational strategies, optimize resource

allocation, and transform business models in response to changing external environments. Recovery refers to the speed and degree to which the real economy can return to its pre-shock operational level or even achieve higher-quality development after a disruption. This resilience is not only reflected at the enterprise level (e.g., a manufacturing firm's ability to switch suppliers quickly) but also at the industrial chain, regional, and national levels (e.g., the ability of a country's manufacturing sector to maintain stable output amid global supply chain tensions).

Notably, the resilience of the real economy is not static but dynamic, evolving with technological progress and institutional changes. The integration of digital technologies has become a key driver of the evolution of real economy resilience, as it enhances the ability of economic entities to perceive risks, respond to changes, and innovate continuously. By clarifying these core concepts, we can establish a theoretical basis for analyzing the interaction mechanism between the digital economy and real economy resilience.

2.2 Theoretical Mechanisms of Digital Economy's Impact on Real Economy Resilience

The digital economy enhances the resilience of the real economy through a multi-channel, multi-level mechanism, which can be summarized into four core paths: optimizing resource allocation efficiency, stimulating continuous innovation, fostering collaborative networks, and improving risk perception and early warning capabilities.

First, the digital economy optimizes resource allocation efficiency by breaking down information asymmetries. In the traditional real economy, information gaps between producers and consumers, as well as between different links in the industrial chain, often lead to mismatches between supply and demand, excessive inventory, and inefficient resource utilization—all of which weaken economic resilience. Digital technologies such as big data and AI enable real-time collection, analysis, and sharing of market information, allowing enterprises to accurately grasp consumer demand trends, optimize production plans, and adjust inventory levels dynamically. For example, retail enterprises can use consumer behavior data to predict sales volume, thereby reducing inventory backlogs and shortage risks; manufacturing enterprises can leverage IoT sensors to monitor the operation status of upstream suppliers in real time, ensuring the stability of raw material supply. This efficient resource allocation not only improves operational efficiency but also reduces the vulnerability of the real economy to external shocks.

Second, the digital economy stimulates continuous innovation, which is the core driver of enhancing real economy resilience. The low marginal cost and strong spillover effects of digital technologies reduce the threshold for innovation, enabling more enterprises—especially small and medium-sized enterprises (SMEs)—to participate in innovative activities. Digital platforms provide a collaborative innovation environment, connecting enterprises, research institutions, and consumers to jointly promote product innovation, process innovation, and business model innovation. For instance, in the manufacturing sector, digital twin technology enables enterprises to simulate production processes in a virtual environment, reducing the cost and risk of process improvement; in the service sector, the

integration of AI and big data has given rise to new business models such as online education, telemedicine, and smart logistics, which have enhanced the adaptability of the service industry to external shocks (e.g., lockdown measures during the pandemic). Moreover, fierce market competition in the digital era forces enterprises to continuously innovate to maintain their competitive advantage, forming a "survival of the fittest" mechanism that enhances the overall resilience of the industry.

Third, the digital economy fosters collaborative networks among economic entities, enhancing the stability of the industrial chain and supply chain. In the traditional real economy, the industrial chain is often characterized by linear, fragmented relationships, making it vulnerable to disruptions in individual links. Digital technologies such as blockchain and cloud computing enable the establishment of transparent, efficient, and interconnected collaborative networks among upstream and downstream enterprises in the industrial chain. These networks facilitate the sharing of information, resources, and risks, enabling enterprises to respond collectively to external shocks. For example, during the COVID-19 pandemic, some manufacturing clusters used industrial Internet platforms to share production capacity, raw materials, and logistics resources, ensuring the continuous operation of the industrial chain. Additionally, the formation of digital collaborative networks has promoted the diversification of supply chain sources, reducing the dependence on a single supplier or region and enhancing the anti-risk ability of the supply chain.

Fourth, the digital economy improves risk perception and early warning capabilities, enabling the real economy to respond to shocks proactively. Digital technologies such as big data analytics and AI can process massive amounts of multi-source data (e.g., market data, meteorological data, policy data) to identify potential risks and issue early warnings. For instance, in the agricultural sector, IoT sensors and big data can monitor weather conditions, soil quality, and pest infestations in real time, enabling farmers to take preventive measures in advance to reduce the impact of natural disasters; in the financial sector, digital risk control systems can analyze the credit status and operational risks of enterprises in real time, reducing the probability of default risks spreading to the real economy. This proactive risk management model has transformed the real economy's response to shocks from "passive coping" to "active prevention," significantly enhancing its resilience.

3. Practical Dilemmas and Challenges in Digital Economy's Influence on Real Economy Resilience

3.1 Digital Divide and Regional/Sectoral Development Imbalances

The digital divide—encompassing gaps in digital infrastructure, digital skills, and digital access—remains a major barrier to the digital economy's inclusive empowerment of real economy resilience. Unlike the simplistic view that the digital divide is merely a lack of internet access, it is a multi-dimensional gap that includes three core layers: infrastructure divide, capability divide, and application divide. The infrastructure divide refers to the gap in the coverage and quality of digital infrastructure (e.g., 5G, fiber-optic networks, data centers) between regions and sectors. For example,

in rural and remote areas, the coverage rate of high-speed internet is significantly lower than that in urban areas, and the cost of accessing digital services is higher, making it difficult for local agricultural and small-scale manufacturing enterprises to participate in the digital economy.

The capability divide refers to the gap in digital literacy and skills between different groups (e.g., urban vs. rural residents, young vs. elderly workers, large enterprises vs. SMEs). Many traditional manufacturing and service industry enterprises—especially SMEs—lack professional digital talents and the ability to apply digital technologies, making it difficult for them to adopt advanced digital tools such as flexible manufacturing systems (FMS) and smart supply chain management systems. For instance, a small-scale textile enterprise in a rural area may lack the funds and technical personnel to implement digital production management systems, resulting in low production efficiency and poor adaptability to market changes.

The application divide refers to the gap in the depth and breadth of digital technology application between regions and sectors. The service industry (e.g., e-commerce, fintech) has achieved rapid digital transformation due to its low dependence on physical assets and high adaptability to digital technologies. In contrast, traditional heavy industries (e.g., steel, coal) and agriculture face greater challenges in digital transformation due to their complex production processes and high capital investment requirements. Regionally, digital ecosystems in developed coastal regions are more mature, with complete digital infrastructure, abundant digital talents, and active innovation, while underdeveloped inland regions lag behind in these aspects.

These imbalances have exacerbated the polarization of the real economy. Regions and sectors with advanced digital development can better withstand external shocks and achieve rapid recovery, while those with backward digital development are more vulnerable to shocks. If left unaddressed, the digital divide will further widen the development gap between regions and sectors, reducing the overall resilience of the national real economy and even triggering systemic risks.

3.2 Barriers and Risks in Traditional Real Economy's Digital Transformation

The digital transformation of the traditional real economy faces a series of interrelated barriers, ranging from cognitive biases to practical operational challenges. At the cognitive level, many enterprise managers hold a conservative attitude toward digital transformation, viewing it as a high-cost, high-risk investment rather than a necessary strategy for enhancing resilience. They are concerned about the long payback period of digital investment, the uncertainty of returns, and the potential disruption to existing business models. This cognitive bias leads to insufficient investment in digital transformation and a lack of long-term strategic planning.

At the technical level, the integration of traditional production lines and supply chains with digital technologies faces significant challenges. Many traditional enterprises have outdated production equipment and fragmented information systems, with inconsistent technical standards and incompatible data interfaces between different systems. This makes it difficult to achieve seamless connection and data sharing between production, sales, and management links. For example, a traditional automobile

parts manufacturer may use different software systems for production scheduling and inventory management, resulting in data silos that prevent real-time coordination between production and inventory, reducing operational efficiency and increasing supply chain risks.

At the organizational and cultural level, the inertia of traditional management models and organizational cultures hinders digital transformation. Traditional enterprises often adopt hierarchical organizational structures, which are characterized by slow decision-making, poor internal collaboration, and low adaptability to change. In contrast, digital transformation requires agile organizational structures, cross-functional collaboration, and a culture of innovation and trial and error. Many employees in traditional enterprises lack the awareness and ability to adapt to digital changes, and resistance to change further slows down the transformation process.

Furthermore, many enterprises' digital transformation remains at a superficial level, focusing only on the online migration of surface-level processes (e.g., establishing an online sales platform or using mobile office software) without touching the core links of production decision-making, R&D innovation, and organizational management. This "superficial digitalization" not only fails to achieve the expected improvement in efficiency and resilience but also wastes valuable resources and may even trigger new operational risks (e.g., conflicts between old and new systems).

3.3 Data Security, Market Monopoly, and Regulatory Lag Issues

Data, as the core production factor of the digital economy, plays a pivotal role in enhancing real economy resilience. However, the collection, circulation, and utilization of data also bring new risks and challenges. First, data security and privacy protection issues are increasingly prominent. The frequent occurrence of data leakage, theft, and abuse incidents not only damages the legitimate rights and interests of consumers and enterprises but also disrupts the normal order of the digital economy. For example, a manufacturing enterprise's core production data leakage may lead to the theft of its technological secrets, affecting its market competitiveness; a retail enterprise's customer information leakage may erode consumer trust and reduce sales. In severe cases, data security incidents may interrupt critical business processes and supply chain collaboration, triggering systemic risks.

Second, the problem of market monopoly in the digital economy is becoming increasingly prominent, inhibiting the resilience of the real economy. A small number of large digital platform enterprises, relying on their advantages in data, technology, and capital, have formed a dominant position in the market, engaging in unfair competition behaviors such as excluding competitors, restricting market access, and exploiting SMEs. For instance, some e-commerce platforms force merchants to "choose one from two" (i.e., only settle on their own platform and not on competing platforms), restricting the development space of SMEs and reducing market competition and innovation vitality. This monopoly behavior not only harms the interests of SMEs but also weakens the overall adaptability and innovation capacity of the real economy, as SMEs are important sources of innovation and employment.

Third, the lag of regulatory systems has failed to effectively respond to the new risks brought by the digital economy. The digital economy develops rapidly, with continuous emergence of new business

models (e.g., platform economy, sharing economy) and new forms of competition, which are beyond the scope of traditional regulatory frameworks. Existing regulatory policies are often fragmented, backward, and lack cross-departmental coordination, leading to regulatory gaps and overlaps. For example, the cross-border flow of data involves multiple regulatory departments (e.g., cyberspace administration, commerce, public security), but there is a lack of unified regulatory standards and coordination mechanisms, making it difficult to effectively regulate cross-border data risks. This regulatory lag not only fails to timely warn and constrain potential risks but also may restrict the healthy development of the digital economy, affecting its ability to empower real economy resilience.

3.4 Insufficient Depth in Digital Technology Integration and Application

Although digital technologies have been widely applied in the real economy, there is a significant gap between the breadth and depth of application, with most applications remaining at a shallow level. Many enterprises have only realized the "digitalization of processes" rather than the "digitalization of core capabilities." For example, some manufacturing enterprises have introduced IoT sensors to monitor equipment operation but have not used the collected data to optimize production processes, predict equipment failures, or drive product innovation. Some service enterprises have established online booking systems but have not used customer data to personalize services or improve customer experience.

One of the main reasons for this insufficient integration depth is the existence of data silos. Due to inconsistent data standards, incompatible technical systems, and insufficient data sharing mechanisms between different departments and enterprises, it is difficult for data to flow freely across the entire value chain. For instance, in a large manufacturing enterprise, the data generated by the production department (e.g., production volume, defect rate) cannot be effectively shared with the R&D department, making it difficult for the R&D department to optimize product design based on production practice. Similarly, the financial data of an enterprise is often isolated from its operational data, affecting the accuracy of financial decision-making and risk assessment.

Another reason is the mismatch between digital solutions and industry-specific needs. Most digital technology suppliers provide generalized solutions that lack customization for the unique production processes, business characteristics, and pain points of specific industries. For example, a digital solution designed for the retail industry may not be suitable for the agricultural sector, which has unique needs such as crop growth monitoring and agricultural product traceability. This mismatch leads to low utilization rates of digital technologies and failure to fully unleash their potential in enhancing real economy resilience.

The shallow integration of digital technologies means that the real economy cannot fully leverage the advantages of digital technologies such as accurate prediction, rapid iteration, and dynamic optimization. When facing external shocks (e.g., supply chain disruptions, sudden changes in market demand), enterprises still rely on traditional experience and rigid plans to cope, resulting in slow response speeds, high adjustment costs, and weak recovery capabilities.

3.5 Digital Talent Shortage and Employment Structure Disruption

The shortage of digital talents is a universal bottleneck restricting the deep integration of the digital economy and the real economy. The digital transformation of the real economy requires a large number of compound talents who possess both professional knowledge of the real economy and digital skills (e.g., data analysis, AI application, digital operation). However, there is a serious imbalance between the supply and demand of such talents in the market. According to relevant reports, the global shortage of digital talents has exceeded millions, and this gap is still widening. Many enterprises—especially SMEs—cannot recruit enough professional digital talents due to limited funds and brand influence, making it difficult to promote in-depth digital transformation.

In addition to the shortage of new talents, the skill updating of existing employees in the real economy is lagging behind the pace of digital technology iteration. The rapid development of digital technologies has fundamentally changed the job requirements of many traditional positions. For example, traditional production line workers now need to master the operation of intelligent equipment; traditional marketers need to be proficient in data analysis and digital marketing tools. However, many existing employees lack the awareness and opportunities to update their skills, leading to a "skill mismatch" between employees and job requirements. This not only affects the efficiency of digital transformation but also increases the risk of unemployment for employees in traditional positions.

The digital transformation of the real economy has also triggered profound changes in the employment structure, bringing phased adjustment pressures. On the one hand, the application of automation equipment and AI technologies has reduced the demand for low-skilled, repetitive jobs (e.g., manual assembly workers, data entry clerks). On the other hand, the demand for emerging digital jobs (e.g., data analysts, AI engineers, digital security specialists) is growing rapidly. This structural adjustment requires workers to actively participate in skill training and career transformation. However, the existing vocational training system is often outdated, with a mismatch between training content and market demand. In addition, the social security system is not yet fully adapted to the changes in the employment structure (e.g., the lack of effective social security coverage for platform workers), which affects the willingness of workers to participate in digital skill training and career transformation.

The talent shortage and employment structure adjustment pressures not only hinder the digital transformation of the real economy but also reduce its resilience. Without sufficient digital talents, enterprises cannot effectively apply digital technologies to enhance their risk resistance capabilities; the instability of the employment structure may affect social stability, which in turn impacts the stable operation of the real economy.

4. Pathways and Strategies to Enhance the Digital Economy's Empowerment of Real Economy Resilience

4.1 Improving Digital Infrastructure and Promoting Inclusive Development

Improving the quality and coverage of digital infrastructure is the foundation for the digital economy to

empower real economy resilience. This requires a two-pronged approach: expanding coverage and improving quality. First, we need to strengthen the construction of digital infrastructure in underdeveloped regions (e.g., rural areas, inland regions) to narrow the regional digital divide. Specifically, we should increase investment in 5G base stations, fiber-optic networks, and IoT sensors in these regions, improve the coverage rate of high-speed internet, and reduce the cost of digital services. For example, we can promote the "digital village" construction project, build a rural digital infrastructure network covering agriculture, rural areas, and farmers, and provide basic digital support for agricultural digital transformation.

Second, we need to optimize the layout of digital infrastructure to meet the specific needs of different industries. For manufacturing clusters, we should deploy industrial IoT identification resolution nodes, edge computing facilities, and cloud data platforms to provide low-latency, high-reliability digital services for intelligent production. For agricultural regions, we should build agricultural IoT monitoring networks to support precision agriculture. For energy-intensive regions, we can build data centers to take advantage of local energy resources, while deploying edge computing facilities in nearby urban areas to meet the real-time computing needs of enterprises.

To promote inclusive development, we need to ensure that all economic entities—especially SMEs and vulnerable groups—can equally access and use digital infrastructure and services. First, we can encourage telecom operators and cloud service providers to launch affordable, standardized digital service packages for SMEs. For example, providing low-cost cloud storage, data analysis tools, and digital operation services to reduce the digital transformation costs of SMEs. Second, we can establish public digital service platforms to provide free or low-cost digital skill training, technical consulting, and solution design services for SMEs. For instance, setting up regional digital transformation service centers to provide "one-stop" services for SMEs, including digital diagnosis, solution customization, and on-site technical support.

Third, we need to improve the digital literacy of the whole society. We can carry out targeted digital skill training for different groups: for enterprise employees, focus on training digital operation and maintenance, data analysis, and other practical skills; for farmers, focus on training the use of agricultural digital tools (e.g., intelligent irrigation systems, agricultural product e-commerce platforms); for the elderly, focus on basic digital skills (e.g., online payment, online shopping) to help them integrate into the digital society. By improving the digital literacy of the whole society, we can narrow the capability divide and lay a solid human resource foundation for the inclusive empowerment of the digital economy.

4.2 Advancing Deep Integration and Full-Industry-Chain Digital Transformation

To achieve the deep integration of the digital economy and the real economy, we need to promote full-industry-chain digital transformation, covering all links from R&D, production, and sales to post-sales services. Leading enterprises in the industrial chain should play a leading role in formulating unified digital standards and specifications for the entire industry chain. These standards should cover

data collection, data format, interface protocols, and information sharing, to break down data silos and realize seamless connection between upstream and downstream enterprises. For example, leading automobile manufacturers can formulate unified digital standards for auto parts suppliers, enabling real-time sharing of production schedules, quality data, and logistics information between suppliers and manufacturers, and improving the efficiency and stability of the supply chain.

Enterprises should focus on the digital transformation of core links to enhance their core competitiveness and resilience. In the R&D link, they can use digital twin, simulation testing, and other technologies to shorten the R&D cycle and reduce R&D costs. In the production link, they can build intelligent production lines based on IoT, AI, and robotics to improve production efficiency and product quality, and realize flexible production that adapts to personalized market demand. In the sales and service links, they can use big data and AI to analyze consumer needs, provide personalized products and services, and establish a full-life-cycle customer service system.

Promoting full-industry-chain digital transformation requires joint efforts from the entire value chain, including SMEs. Industry associations can play a coordinating role, aggregating the digital needs of SMEs and cooperating with digital technology suppliers to develop low-cost, standardized digital solutions for the industry. These solutions can be deployed on industrial Internet platforms, enabling SMEs to access advanced digital technologies and services at a low cost. For example, a textile industry association can cooperate with a cloud service provider to build a textile industry Internet platform, providing SMEs with digital services such as intelligent production scheduling, fabric quality testing, and online order management.

In addition, we need to strengthen the integration of digital technologies with green development to enhance the sustainable resilience of the real economy. For example, using digital technologies to monitor and optimize energy consumption in the production process, reduce carbon emissions, and improve the environmental sustainability of enterprises. By combining digital transformation with green transformation, we can build a more resilient real economy that is adaptable to both economic and environmental shocks.

4.3 Strengthening Data Governance and Refining the Digital Market Environment

Strengthening data governance is crucial to ensuring the safe and orderly circulation of data and releasing the value of data elements. First, we need to improve the legal system for data governance, clarifying the rights and obligations of data subjects, data collectors, and data users. We should formulate and improve laws and regulations such as the Data Security Law and the Personal Information Protection Law, and refine supporting rules to standardize the collection, storage, use, and transmission of data. Second, we need to establish a hierarchical and classified data management system. Enterprises should classify and grade their data according to its importance and sensitivity, and adopt corresponding security protection measures (e.g., encrypted storage, access control) to prevent data security risks.

Third, we need to promote the construction of data exchange platforms to facilitate the safe and orderly

circulation of data. We can build government-led public data exchange platforms to promote the sharing of public data between government departments and between government and enterprises. For specific industries, we can build industry-specific data exchange platforms to realize data sharing and collaboration between enterprises in the industry. At the same time, we need to establish a standardized data transaction mechanism, including data transaction contracts, pricing mechanisms, and dispute resolution mechanisms, to protect the legitimate rights and interests of data transaction participants.

Refining the digital market environment requires improving the regulatory system to maintain fair competition and prevent market monopoly. First, we need to establish a regulatory framework adapted to the digital economy, focusing on regulating the competitive behavior of platform enterprises. We should strengthen the supervision of unfair competition behaviors such as "choose one from two," data monopoly, and price discrimination, and investigate and punish illegal acts in accordance with the law. Second, we need to improve the regulatory technology and methods, using digital technologies such as AI and big data to carry out intelligent regulation. For example, building a digital market supervision platform to monitor the operation of platform enterprises in real time and early warn of potential monopoly risks.

Third, we need to establish a multi-participatory regulatory system, including government supervision, industry self-regulation, and social supervision. We should give full play to the role of industry associations in formulating industry self-regulation rules and guiding enterprises to operate in accordance with the law. We should also strengthen social supervision, improve the reporting mechanism for illegal acts, and encourage consumers and the media to participate in the supervision of the digital market. By improving the regulatory system, we can create a fair, transparent, and orderly digital market environment, which is conducive to the healthy development of the digital economy and the enhancement of real economy resilience.

4.4 Encouraging Technological Innovation and Building Industrial Ecosystems

Encouraging technological innovation is the core driving force for enhancing the digital economy's ability to empower real economy resilience. First, we need to increase investment in digital technology R&D. The government should increase financial support for basic research and key core technologies in the digital field (e.g., AI chips, blockchain, and industrial software) and guide enterprises to increase R&D investment. We can establish a government-led, enterprise-participated innovation fund to support the R&D and application of digital technologies in the real economy. For example, supporting SMEs in developing modular intelligent manufacturing systems and intelligent inventory forecasting software that are suitable for their own needs.

Second, we need to improve the transformation mechanism of scientific and technological achievements, promoting the integration of digital technology R&D and practical application. We should strengthen the cooperation between universities, research institutions, and enterprises, building a collaborative innovation platform to realize the sharing of resources and complementary advantages. We can encourage enterprises to establish cross-functional project teams, responsible for the R&D,

implementation, and evaluation of digital technology projects, to accelerate the transformation of technological achievements into productivity.

Building a digital industrial ecosystem is an important way to enhance the overall resilience of the real economy. Leading enterprises should take the lead in building open industry cloud platforms, opening up their digital resources, technologies, and capabilities to upstream and downstream enterprises in the industry. For example, a large logistics enterprise can build an open logistics digital platform, providing small logistics companies with services such as route optimization, cargo matching, and real-time tracking. Local governments can support the construction of regional shared manufacturing centers and digital supply chain collaboration platforms, providing SMEs with advanced digital services such as data analysis, remote operation and maintenance, and cloud manufacturing.

We also need to promote cross-industry innovation and collaboration, breaking down the barriers between industries. For example, introducing user experience design concepts from the consumer electronics industry into the product development of traditional equipment manufacturing, and combining agricultural technology with digital technology to develop precision agriculture. By promoting cross-industry collaboration, we can stimulate innovative vitality and build a more diverse and resilient industrial ecosystem.

4.5 Reinforcing Digital Talent Development and Social Security Systems

Reinforcing digital talent development requires establishing a talent training system that adapts to the needs of the digital economy and the real economy. First, universities and vocational colleges should adjust their professional settings and curriculum systems, increasing the proportion of courses related to digital technologies (e.g., data analysis, AI application, industrial Internet). We should strengthen the training of compound talents, combining professional knowledge of the real economy (e.g., manufacturing, agriculture) with digital skills. For example, setting up majors such as “digital manufacturing” and “smart agriculture” to cultivate talents who understand both industry and digital technology.

Second, we need to strengthen the cooperation between schools and enterprises in talent training. Enterprises can cooperate with universities and vocational colleges to build off-campus training bases, providing students with practical training opportunities in real digital production environments. We can also carry out order-based training, where enterprises put forward talent demand standards, and schools customize training programs to ensure that the trained talents can meet the actual needs of enterprises.

Third, we need to improve the talent incentive mechanism to attract and retain digital talents. Enterprises should improve the salary and welfare system for digital talents, provide them with broad career development space, and encourage innovation and entrepreneurship. Local governments can introduce preferential policies for digital talents, such as housing subsidies, educational support, and tax incentives, to attract high-end digital talents to work and start businesses in local areas.

Adapting the social security system to the changes in the employment structure is crucial to ensuring the smooth progress of digital transformation. First, we need to improve the vocational training system,

focusing on training the digital skills of existing employees. We can carry out targeted training programs for different industries and positions, and subsidize the training costs of enterprises and employees. Second, we need to expand the coverage of social security to include platform workers, freelancers, and other new types of employment. We should improve the flexible social security participation and payment methods to ensure that these workers can enjoy basic social security benefits.

Third, we need to establish a career transition support system for workers affected by digital transformation. We can provide employment guidance, career counseling, and re-employment training for workers who lose their jobs due to automation and digitalization, helping them find new jobs. By improving the social security system and career transition support system, we can reduce the social risks brought by digital transformation and ensure the stable development of the real economy.

5. Conclusion

The digital economy has become an important driving force for enhancing the resilience of the real economy, bringing profound changes to the operational model, industrial structure, and risk management methods of the real economy. Through optimizing resource allocation, stimulating innovation, fostering collaborative networks, and improving risk perception capabilities, the digital economy significantly enhances the resistance, adaptability, and recovery capacity of the real economy. However, the process of the digital economy empowering the real economy is still facing many challenges, such as the digital divide, technical integration barriers, data security risks, talent shortages, and regulatory lag. These challenges not only restrict the depth and breadth of digital transformation but also affect the overall resilience of the real economy.

To fully unleash the potential of the digital economy in empowering real economy resilience, we need to take a comprehensive and systematic approach. We should improve digital infrastructure to promote inclusive development, advance full-industry-chain digital transformation to achieve deep integration, strengthen data governance to refine the digital market environment, encourage technological innovation to build a resilient industrial ecosystem, and reinforce digital talent development and social security systems to provide talent and institutional support. Only by addressing these challenges and implementing targeted strategies can we realize the deep integration of the digital economy and the real economy, and build a more resilient, inclusive, and sustainable real economy.

Looking to the future, with the continuous progress of digital technologies and the improvement of supporting systems, the digital economy's empowering effect on real economy resilience will be further enhanced. However, we also need to recognize that the relationship between the digital economy and real economy resilience is dynamic and evolving, and new challenges and problems will continue to emerge. Therefore, future research should focus on the latest developments in the digital economy (e.g., the application of generative AI, the development of the metaverse) and their impact on real economy resilience, and continuously adjust and improve relevant theories and strategies to adapt to the

changing economic environment.

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